

Claims

- [c1] 1.A method for controlling engine operation, the engine having an exhaust system including an air introduction device and an exhaust gas sensor, the method comprising:
after an engine cold start, operating the engine with a rich air-fuel ratio and adding air via said air introduction device; and
during said operation:
estimating an air amount introduced into the exhaust from said air introduction device based at least on an operating condition and an adaptively learned parameter;
determining if the sensor is operating;
in response to said determination, updating said adaptively learned parameter based on said exhaust gas sensor; and
injecting a fuel injection amount into the engine based on said estimated air amount.
- [c2] 2.The method recited in Claim 1 wherein said sensor is an exhaust air-fuel ratio sensor.
- [c3] 3.The method recited in Claim 1 wherein said updating of said adaptively learned parameter occurs whenever the sensor switches from lean to rich or from rich to lean.
- [c4] 4.The method recited in Claim 1 wherein said operating condition is at least one of a pump voltage or an ambient environmental condition.
- [c5] 5.A method for controlling engine operation, the engine having an exhaust system including an air introduction device and an exhaust gas sensor, the method comprising:
estimating an air amount introduced into the exhaust from said air introduction device based at least on an operating condition;
injecting a fuel injection amount into the engine based on said estimated air amount;
measuring an exhaust gas condition based on the sensor; and
adjusting said estimating of said air amount based on said measured exhaust

gas condition.

- [c6] 6.The method recited in Claim 5 wherein said exhaust gas condition is an exhaust gas air-fuel ratio.
- [c7] 7.The method recited in Claim 5 wherein said operating condition is ambient pressure.
- [c8] 8.The method recited in Claim 5 wherein said operating condition is ambient temperature.
- [c9] 9.The method recited in Claim 5 wherein said operating condition pump voltage.
- [c10] 10.The method recited in Claim 5 wherein said operating condition is exhaust pressure.
- [c11] 11.The method recited in Claim 5 wherein said operating condition is engine airflow.
- [c12] 12.The method recited in Claim 6 wherein said adjusting further comprises determining an air-fuel ratio error between a desired exhaust mixture air-fuel ratio and said measured exhaust gas air-fuel ratio, and determining a correction value based on said air-fuel ratio error.
- [c13] 13.The method recited in Claim 13 further comprises storing said correction value for future engine starts.
- [c14] 14.The method recited in Claim 5 wherein said adjusting is enabled during closed loop air-fuel control conditions when the air introduction device is operating.
- [c15] 15.The method recited in Claim 14 wherein said air introduction device is enabled when exhaust gas temperature is below a first limit and above a second limit.
- [c16] 16.The method recited in Claim 5 wherein said fuel injection amount is further based on a desired exhaust mixture air-fuel ratio, said mixture including burnt

combustion gasses and introduced air.

- [c17] 17.The method recited in Claim 16 wherein said desired exhaust mixture air-fuel ratio is substantially stoichiometric.
- [c18] 18.The method recited in Claim 16 wherein said fuel injection amount is further based on said measured exhaust gas condition.
- [c19] 19.A system, comprising:
an engine having an exhaust system;
an air pump coupled to said engine exhaust that pumps ambient air into said exhaust;
an exhaust sensor coupled to said exhaust system that provides an indication of exhaust air-fuel ratio; and
a controller for estimating an air amount introduced into said exhaust from said air introduction device based at least on a pump voltage, injecting a fuel injection amount into the engine based on said estimated air amount, measuring an exhaust gas condition based on the sensor, and adjusting said estimating of said air amount based on said measured exhaust gas condition.
- [c20] 20.The system recited in Claim 19 wherein said exhaust gas sensor is an exhaust gas oxygen sensor.
- [c21] 21.The system recited in Claim 19 wherein said exhaust gas sensor is a switching exhaust gas oxygen sensor.
- [c22] 22.The system recited in Claim 19 further comprising a catalyst in the engine exhaust, said catalyst being downstream of said sensor and said air pump.
- [c23] 23.A method for controlling engine operation, the engine having an exhaust system including an air introduction device and an exhaust gas sensor, the method comprising:
estimating an air amount introduced into the exhaust from said air introduction device based at least on a pump voltage and atmospheric pressure;
measuring an exhaust gas condition based on the sensor;
injecting a fuel injection amount into the engine based on said estimated air

amount and said measured exhaust gas condition;
determining a correction to said air amount estimate based on said measured exhaust gas condition and a desired exhaust gas mixture air-fuel ratio, wherein said mixture includes burnt exhaust gas and introduced air; and
adjusting said fuel injection based on said correction.

- [c24] 24.A method for controlling engine operation, the engine having an exhaust system including an air introduction device and an exhaust gas sensor, the method comprising:
- estimating an air amount introduced into the exhaust from said air introduction device based at least on an operating condition;
 - determining if the sensor is operating;
 - in response to said determination, operating in a first mode when said sensor is operating, said first mode comprising:
 - injecting a first fuel injection amount into the engine based on said estimated air amount;
 - measuring an exhaust gas condition based on the sensor; and
 - adjusting said estimating of said air amount based on said measured exhaust gas condition; and
 - in response to said determination, operating in a second mode when said sensor is not operating, said second mode comprising:
 - injecting a second fuel injection amount into the engine based on said adjusted estimated air amount.